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⑯ Improved sprayable portland cement-based fireproofing compositions.

⑯ Sprayable fireproofing compositions for structural members such as steel columns are provided, as well as a method of applying multiple coatings thereof. The compositions comprise a Portland cement-based material, stucco, a high density aggregate and an accelerator. The compositions eliminate the long setting times typical of Portland cement-based materials, and improve the hangability thereof. The product is produced by dry blending a mixture of Portland cement, a high density aggregate, stucco (calcium sulfate hemi-hydrate) and optionally, a stucco set retarder and shredded polystyrene aggregate. Upon the addition of water, sprayable slurries are formed which can be pumped to the point of application. An accelerator is added in close proximity to the point of injection. The slurries adhere to the structural member in the slurred state and after setting to provide excellent fire and heat protection. Because of the relative quick setting time of the slurry upon spray application, multiple coatings can be applied within the same working day.

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This application is a continuation-in-part of Serial No. 869,605 filed April 16, 1992.

FIELD OF THE INVENTION

5 The present invention relates to sprayable fireproofing compositions.

BACKGROUND OF THE INVENTION

10 It is well known to spray apply hydraulic cementitious slurries to metal structural members in order to provide a heat resistant coating thereon. U.S. Patent Nos. 3,719,513 and 3,839,059 disclose gypsum-based formulations which contain, in addition to the gypsum binder, a lightweight inorganic aggregate such as vermiculite, a fibrous substance such as cellulose and an air entraining agent. Such slurries are generally prepared at ground level and are pumped to the point of application, where they are spray applied to the substrate. Often the point of application exceeds 20 or 30 stories where high rise construction is involved. Accordingly, pumpability of the slurries is an important criteria in their formulation and preparation. Thus, they must be able to hold the large quantity of water that renders them capable of being pumped easily and to great heights, yet they must retain a consistency sufficient to prevent segregation or settling of ingredients and permit adequate yield or coverage of the substrate at a given thickness. The coating mixes must adhere to the substrate both in the slurred state and in the dry state. Also, the mix must set without undue expansion or shrinkage which could result in the formation of cracks that would seriously deter from the insulative value of the dry coating.

15 U.S. patent No. 4,751,024, the disclosure of which is incorporated herein by reference, teaches sprayable cementitious compositions containing shredded polystyrene as a lightweight aggregate in fireproofing compositions. The cementitious binder is preferably gypsum, but may instead be Portland cement. Indeed, Portland cement is typically used as the binder in applications involving high traffic areas, since the cement tends to be stronger than gypsum.

20 However, one problem associated with Portland cement-based fireproofing compositions is the relatively poor hangability (the thickness of material that can be applied in a single application) thereof with respect to gypsum-based compositions, since water tends to segregate in Portland cement mixtures in view of the relatively slow hydration process. In addition, in view of the relatively long time it takes for Portland cement to set, only one spray application can be made per day on a given substrate. Where the thickness of that spray application is insufficient, a second application cannot be made until the first application sets. Premature attempts to coat a second application result in fall off. If multiple applications cannot be made in a typical eight hour work day, labor costs necessarily increase, as does the time in which a job can be completed.

25 Unlike gypsum-based compositions, which can be easily accelerated with alum, such as in close proximity to the spray nozzle as set forth in U.S. Patent Nos. 4,904,503 and 4,934,596 (the disclosures of which are herein incorporated by reference), alum does not accelerate Portland cement in sufficient time to allow multiple passes in one day. In addition, sodium aluminate should not be used as an accelerator, in view of the corrosive nature of the sodium aluminate, which causes severe corrosion to the hot rolled steel substrates.

30 Accordingly, the fireproofing industry has long sought a Portland cement-based sprayable fireproofing material that can be applied to substrates such as steel in multiple applications per day, and that exhibits improved hangability notwithstanding such multiple applications.

SUMMARY OF THE INVENTION

35 The problems of the prior art have been overcome by the instant invention, which provides a sprayable fireproofing material which eliminates the aforementioned long setting times and improves the hangability of Portland cement-based compositions. In general, the sprayable fireproofing compositions of the instant invention comprise a Portland cement based material that is mixed with water in a conventional paddle mixer and is pumped through various types of equipment. The material is spray applied onto steel beams and columns. 40 The product is produced by dry blending a mixture of Portland cement, stucco (defined herein as calcium sulfate hemi-hydrate), and other additives, such as shredded expanded polystyrene, starch, adhesives and cement strength enhancers. Upon the addition of water, the dry compositions form pumpable, sprayable slurries. Preferably an accelerator is added, most preferably in close proximity to the point of injection.

DETAILED DESCRIPTION OF THE INVENTION

45 The inventor of the present invention has found that causing a set acceleration of the Portland cement-based fireproofing enables multiple pass applications and improved hangability. That set acceleration can be

caused by the addition of stucco, which can be sufficiently retarded to allow pumping and spraying, such as with a retarder, preferably a proteinaceous high strength retarder (commercially available from U.S. Gypsum), in an amount of about 0 to about 1.0% by weight of the composition, preferably about 0 to 0.6%. The amount of retarder may vary, depending upon the particular cement and stucco being used. The acceleration of the set is evidenced by initial quicker stiffening of the Portland cement/stucco matrix. The addition of aluminum sulfate, preferably in close proximity to the point of injection such as in accordance with the method and apparatus disclosed in U.S. Patent No. 4,904,503 or U.S Patent No. 4,934,596 increases the speed of the setting process. This quicker set is sufficient to allow a second application of material to be sprayed in a few hours. In particular, when the Portland cement/stucco formulation is injected with alum, the stucco sets, which causes a stiffening of the Portland cement matrix and quickens the increase of the cohesive strength of the composition. Also, the setting of the stucco results in a quicker mechanical attachment to the substrate. This attachment is strong enough to allow a second application without fall off within a period of eight hours, or one working day. The injection of alum in proximity to the point of injection enables quick setting of the material in a particular spot (i.e., on the substrate rather than in the hopper where the composition is mixed).

The instant fireproofing compositions preferably contain shredded expanded polystyrene as an aggregate. The hangability of the instant composition may depend in part on minimizing the amount of non-shredded expanded polystyrene in the composition. The "shreddedness" of the expanded polystyrene preferably conforms to a particular particle size distribution expressed in terms of the amount of particles retained on a standard #12 sieve (having 0.0661 inch holes), and the amount of particles passing through a standard #30 sieve and retained on a #325 sieve, as determined in accordance with the method described in U.S. Patent No. 4,989,464 (the disclosure of which is hereby incorporated by reference). Suitable amounts of particles retained on the #12 sieve, expressed as a weight percent, are from about 0 to about 20%, with from about 0 to about 10% being preferred. Suitable amounts of particles passing through a #30 sieve (having 0.0234 inch holes) and retained on a #325 sieve (having 0.0017 inch holes) are less than about 40% by weight, preferably less than about 30%.

Since the instant fireproofing compositions are typically transported to the building site as dry mixtures, and are formed into slurries upon the addition of an appropriate amount of water, the preparation and application processes may span many hours and thus the setting time of the mix is generally heavily retarded to provide an acceptable field pot life. This retarding in the mixer contradicts the desired quick setting time upon spray application, and thus a delicate balance of retarding and accelerating is difficult to achieve. Obviously, were the mixture to stiffen substantially in the hopper, it would be rendered non-pumpable and therefore would be useless for the intended application. By adding retarder to the stucco, the retarded material does not stiffen as quickly in the mixer, and the retarder does not have any significant effect on the quick stiffening at the nozzle. For these reasons, the addition of retarder is preferred.

Any set accelerating agent capable of satisfactorily offsetting the retardation of the slurry without deleteriously effecting the slurry or the substrate which is the subject of the application can be used. Preferably the accelerator is used in an amount sufficient to sufficiently set the slurry within 1.5 hours of spray application to allow for a second spray application without fall off. The particular amount required will depend upon the type of accelerator, as well as the nature of the various other components of the fireproofing composition. Examples of useful accelerators include aluminum sulfate, aluminum nitrate, ferric nitrate, ferric sulfate, potassium sulfate, sulfuric acid, sodium carbonate, sodium bicarbonate and acetic acid, with alum being especially preferred.

The present invention is applicable to Portland cement types 1 through 5, although types 1 is especially preferred. The dry mix has a bulk density in the 10 to 65 pcf range, preferably in the 12 to 15 pcf range for low density mixes, and in the 30-55 pcf range for high density mixes. The final dry density of the product is in the 15 to 65 pct range, preferably the 22 to 26 pcf range for low density products, and in the 40-50 pcf range for high density products. In the higher density product, less Portland cement than in the lower density product is used (and therefore less water is used), and a high density aggregate such as sand or bauxite or a mixture thereof is added. Any suitable grade of sand may be used, as long as it does not deleteriously affect the hangability of the product or pumpability of the mix. Preferably the same is oven dried. The preferred bauxite is hydrated and is a mixture of coarse and fine grades. In addition, the amount of lightweight aggregate such as shredded polystyrene is decreased in the high density product. The dry material is mixed with water at a ratio of 0.5:1 - 1.6:1 (water:solids). A suitable product can be produced in accordance with the invention by dry blending a mixture of the following:

5.	Portland cement	30 - 90%
	Stucco	4 - 30%
	Retarder	0 - 1%
10	Shredded polystyrene	0 - 5%, preferably 2 - 3%
	Clay	2 - 8%
15	Cellulose (aggregate)	0 - 8%
	Air entrainment	0.2 - 2%
	Glass fibers	0 - 4%
	methyl cellulose	0 - 1%
	sand or bauxite	0 - 60%
	vinyl acetate	0 - 5%

20 A preferred low density product includes the following range of ingredients:

25	Portland cement	67 - 74%
	Stucco	12 - 18%
	Retarder	0 - 0.6%
30	Shredded polystyrene	2.5 - 3%,
	Clay (thickener)	2 - 6%
35	Cellulose	2 - 6%
	Air entrainment	0.2 - 0.5%
40	Glass fibers	1.5 - 3%
	methyl cellulose	0.2 - 0.5%
45	biocide (Amical/wp sold by Angus Chemical)	0.02%, or an amount sufficient to p r e v e n t d e l e t e r i o u s formation of bacteria
50		

A preferred high density product includes the following range of ingredients:

5	Portland cement	40 - 50%
	Stucco	12 - 18%
10	Retarder	0 - 0.6%
	Shredded polystyrene	0 - 1.5%,
	Clay (thickener)	2 - 6%
15	Cellulose	2 - 6%
	Air entrainment	0.2 - 0.5%
	Glass fibers	1.5 - 3%
20	methyl cellulose	0.2 - 0.5%
	biocide (Amical/wp sold by Angus Chemical)	0.02%, or an amount sufficient to prevent deleterious formation of bacteria
	sand or bauxite	40-55%
	vinyl acetate	1-3%

Preferably the aluminum sulfate set accelerator is used as a 37% solution and is injected into the slurry at the spray nozzle at a level up to 3%.

25 Additional optional ingredients may be added, such as glass fibers to control shrinkage, methyl cellulose or other suitable thickeners known to those skilled in the art, air entraining agents such as sodium lauryl sulfate, and a biocide to inhibit bacterial formation.

30 In employing the fireproofing compositions in accordance with the present invention, a second application can be spray applied within about 1 to 2 hours, preferably within about 1.5 hours of the first application without fall off. Improved hangability also resulted; a single application typically could be spray applied to a thickness of about 3/4 - 1 inch, and was in fact spray applied to a thickness of as much as 1.5 inches, whereas conventional Portland cement-based compositions typically could be hung to thicknesses of only 1/2 to 5/8 inches.

EXAMPLE 1

35

The following formulations were prepared:

40	Formulation	% Stucco	% Cement	Dry Bulk Density	NozL. Vicat(MM)@1 Hr	
					Uninjected	Injected
	Control	0	85.7	12.4	14.5	11.5
	1	8	77.5	11.8	12	9.5
45	2	12	73.4	12.6	11	8.5
	3	16	69.3	13.2	9.5	6.5
	4	24	61.2	12.3	10.5	8
50	5	16	42.0	35.2	9.0	7.0
	6	16	36.0	63.5	10.0	6.5

55 The cement in each of the above batches was type 1 Portland cement. Each batch was spray applied to a steel structural member, with 2.6% alum added in accordance with the teachings of U.S. patent No. 4,904,503. The 12% and 16% batches set sufficiently within 1 to 1.5 hours so that a second application could be applied. The 12% and 16% first application had a thickness of 3/4" to 7/8", with a total average thickness after the second application up to 1.5-2". With regard to the control, the first application amounted to a coating of up to 5/8

of an inch. A second pass (amounting to a total coating thickness of 1.5 inches) was attempted after 1.5 hours, but fall off was encountered. In particular, the application of a second pass caused fall off of not only the second application, but also some of the coating from a first application. This suggests that the coating of the first application did not sufficiently bond to the substrate within the 1.5 hour time period.

5 The vicat data is a measurement of the flow and stiffness of the material. The stiffness is generally an indication of how well the product hangs. The lower the vicat reading, the stiffer the product. Preferably the vicat number is below about 10 mm, most preferably the reading is about 8 mm or less. Although the vicat reading of formulation number 4 in Example 1 seems excellent, in fact that formulation, containing 24% stucco, proved to be too stiff in the hopper, that is, the workability was poor. In order to render such a formulation commercially 10 viable, additional water would have been necessary, thereby increasing the final vicat number of the useable composition.

Claims

- 15 1. A Portland cement-based sprayable fireproofing composition, comprising a dry blend of 30-90% Portland cement and 4-30% stucco, said dry blend having a bulk density ranging from about 480 to 880 Kg/m³ (30 to 55 lb/ft³), and up to 3 % of an accelerator for said composition.
- 20 2. The sprayable fireproofing composition of claim 1, further comprising a stucco set retarder.
3. The sprayable fireproofing composition of claim 1 or 2, further comprising shredded polystyrene.
- 25 4. The sprayable fireproofing composition of claim 1, 2 or 3, further comprising a high density aggregate, preferably as from 40 to 55 % of the fireproofing composition, selected from the group consisting of sand, bauxite and a mixture thereof.
- 30 5. A method of applying multiple coatings of a sprayable fireproofing composition to a steel substrate comprising dry blending a mixture comprising 30-90% Portland cement and 4-30% stucco, the resulting dry blend having a bulk density of 480 to 880 Kg/m³ (30-55 lb/ft³); adding water thereto to form a sprayable slurry; conveying said slurry to a spray nozzle; introducing a set accelerating agent into said slurry before, during or after said conveyance and in close proximity to said nozzle; spraying a first coat of said slurry on to said substrate; allowing said first coat to set sufficiently to hold a second coat; and spraying a second coat of said slurry thereon within eight hours of spraying said first coat.
- 35 6. The method of claim 5, wherein said dry blending step further comprises adding a stucco set retarder to said mixture.
- 40 7. The method of claim 5 or 6, wherein said dry blending step further comprises adding a high density aggregate selected from the group consisting of sand, bauxite and a mixture thereof.
8. The method of claim 5, 6 or 7, wherein said stucco, stucco set retarder and accelerator are provided in an amount sufficient to allow said slurry, upon application to said substrate, to set within 1.5 hours.
- 45 9. The method of any one of claims 5 to 8, wherein said first coat of said slurry is spray applied to a thickness exceeding 15.9 mm (5/8 inches).
10. The method of any one of claims 5 to 9, wherein the average total thickness of said first and second coats of said slurry is about 3.8 to 5.08 cm (1.5 to 2 inches).
- 50 11. The method of any one of claims 5 to 10, where said dry blending step further comprises adding shredded polystyrene to said mixture.

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(54) **Improved sprayable portland cement-based fireproofing compositions**

(57) Sprayable fireproofing compositions for structural members such as steel columns are provided, as well as a method of applying multiple coatings thereof. The compositions comprise a Portland cement-based material, stucco, a high density aggregate and an accelerator. The compositions eliminate the long setting times typical of Portland cement-based materials, and improve the hangability thereof. The product is produced by dry blending a mixture of Portland cement, a high density aggregate, stucco (calcium sulfate hemi-

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EUROPEAN SEARCH REPORT

Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT									
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)						
X	CHEMICAL ABSTRACTS, vol. 104, no. 18, 5 May 1966 Columbus, Ohio, US; abstract no. 154687g, page 364; * abstract *	1,2,4	C04B28/14 C04B28/02 C04B18/24 C04B28/04 C04B11/30 //(C04B28/14, 7:02,14:06, 14:30,16:08)						
Y	& JP-A-60 251 160 ---	3,5-11							
Y,D	US-A-4 904 503 (HILTON D.M.) * the whole document *	3,5-11							
A	* examples 1,5 *	1,2,4							
X	US-A-2 837 436 (CHAPMAN E.P.) * column 2, line 63 - column 3, line 55; claims 1-5 *	1,4							
X	US-A-1 923 370 (HANSEN W.C.) * page 1, line 47 - line 95 *	1							
A	US-A-4 036 659 (STUDE D.L.) * column 1, line 56 - line 68 * * column 4, line 48 - line 57 *	1-4	TECHNICAL FIELDS SEARCHED (Int.Cl.6)						
A,D	US-A-4 751 024 (SHU L.S.) * column 3, line 6 - line 13; claims 1-5 *	1,3,11	C04B						
A	US-A-4 494 990 (HARRIS H.A.) * column 3, line 67 - column 4, line 8; claims 1-6; example 1 * * column 5, line 31-36 *	1-7							
A,D	US-A-4 934 596 (HILTON D.M.) * column 1, line 38 - column 2, line 25 * * column 5, line 8 - line 22 *	1-8							
<p>The present search report has been drawn up for all claims</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">Place of search</td> <td style="width: 33%;">Date of completion of the search</td> <td style="width: 33%;">Examiner</td> </tr> <tr> <td>THE HAGUE</td> <td>4 March 1996</td> <td>Bombeke, M</td> </tr> </table>				Place of search	Date of completion of the search	Examiner	THE HAGUE	4 March 1996	Bombeke, M
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CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document							
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document									